

COURSE OUTLINE

Course Title: NIMS Precision Machining

CBEDS Title: Machine Tool Operation

CBEDS No.: 5607

Job Titles:	DOT No.
Machinist Apprentice	600.280-034
Tool Dresser	601.682-010
Turret Lathe Operator	604.380-026
Engine Lathe Operator	604.685-026
Numerical Control Operator	605.380-010
Milling Machine Operator	605.685-030
Drill Press Operator	606.682-014
Cut-Off Saw Operator	607.682-010

Course Description:

This standards-based course provides students with the ability to become credentialed in metalworking skill areas that are nationally recognized and are portable. The two-level program is certified by the National Institute for Metalworking Skills, Inc. In Level I, students will learn core tool and machining skills in three major areas: basic bench operations, basic metal cutting operations, and basic inspection and quality assurance functions. In Level II, students will learn more complex machining skills along with computer numerical control (CNC) principles, angular measurements, and additional auxiliary equipment. Integrated throughout the course are career preparation standards, which include communication, interpersonal skills, problem solving, and skills necessary to seek and keep a job.

Industry-based internships in state-of-the-art machining facilities, both paid and nonpaid, are an integral part of the program design with summer and school year participation. Youth organizations will provide technological and leadership skills as a part of the class activities.

Prerequisites: 16 years of age or junior in high school

Total Hours: 1,080 (variable)

NIMS PRECISION MACHINING COURSE OUTLINE

- I. ORIENTATION 30**
- A. Demonstrate knowledge of course outline.
 - B. Demonstrates awareness of course objectives and competencies.
 - C. Introduction to math problems related to the metalworking industry.
 - D. Introduce the value of participation in youth organizations.
- II. ESSENTIAL EMPLOYABILITY SKILLS/CAREER PREPARATION/SCANS SKILLS**
- A. ATTITUDES AND BEHAVIOR**
- The learner will:
- 1. Demonstrate promptness and attend class regularly.
 - 2. Demonstrate appropriate personal grooming and dress.
 - 3. Follow instructions.
- B. HUMAN RELATIONS**
- The learner will:
- 1. Practice courtesy.
 - 2. Develop and maintain acceptable working relations with peers.
 - 3. Demonstrate respect for position of sponsor/supervisor and a positive cooperative attitude.
- C. JOB SEARCH SKILLS**
- The learner will:
- 1. Prepare a written inventory of personal data or résumé.
 - 2. Locate job opportunities through use of want ads, placement agencies, or journals.
 - 3. Visit at least two facilities related to area of training and observe jobs performed.
 - 4. Complete a job application correctly.
 - 5. Prepare for and critique a simulated employment interview.
 - 6. Discuss employee benefits and rights as related to the specific occupational job area, including gender equity and equal opportunity employment.
 - 7. Identify acceptable procedures to leave a job.
- D. PORTFOLIO PREPARATION**
- The learner will:
- 1. Prepare a finished professional portfolio of best projects.

E. FOUNDATION – SECRETARY’S COMMISSION ON ACHIEVING NECESSARY SKILLS (SCANS)

The learner will:

1. Perform basic computations and approaches to practical problems by choosing appropriately from a variety of mathematical practices.
2. Recognize problems and devise and implement a plan of action.
3. Assess self accurately, set personal goals, monitor progress, and exhibit self-control.

III. CONTENT SKILL AREAS

A. SAFETY

1. The learner will receive safety instruction through oral, visual, tactile, and cognitive methodologies. This should include, but not be limited to, paper/computer testing, lecture, and demonstrations. An oral examination will be administered on the proper sequence of operations and will differentiate between safe and unsafe practices.
2. The learner must demonstrate safe practices on all equipment through successful performance on written and oral tests (matrixed examinations), and real-time demonstrations to the instructor (tools, equipment, materials). Examination preparation activities will include reading, writing, technical explanations (oral), and demonstration techniques.

The learner will:

- a. Demonstrate knowledge of classroom procedures and earthquake, fire, and emergency drills.
- b. Know and demonstrate proper safety procedures for handling equipment.
- c. Satisfactorily complete a written safety exam.
- d. Demonstrate safe practices on all equipment through application.
- e. Demonstrate knowledge and understanding of handling hazardous materials.
- f. Demonstrate interpretation of Material Safety Data Sheets (MSDS's) in shop environment.
- g. Describe employee accident procedures.

B. LEGAL CONSIDERATIONS

The learner will:

1. Demonstrate ethical responsibility.
2. Understand loss prevention/shrinkage from internal theft and inventory loss.
3. Identify and protect against robbery and suspected theft.
4. Understand the consequences of theft, loss, and misuse of property.

C. LEADERSHIP SKILLS

The learner will:

1. Display appropriate professional behavior via initiative, creativity, self-control, and interest/enthusiasm.
2. Demonstrate leadership skills by working independently, making appropriate decisions, working well with others, and taking constructive criticism.

1.0 CONTENT COMPETENCIES - LEVEL I (See Crosswalk)

1.1. **Module 1: Task Planning and Management** 30

Designed to allow the student hands-on skill advancement in task planning and management. Emphasis will be on part process planning and all work necessary to produce route and process sheets.

Task Process Planning: Develop a process plan for a part requiring milling, drilling, turning, or grinding. Complete an operation sheet detailing the process plan and required speeds, feeds, depth of cuts, and coolant needs.

Performance Standard: Given a detail drawing of a part requiring milling, drilling, turning, and grinding, oral instructions, and appropriate references, the student is required to formulate a set of strategies specifying the required speeds and feeds, depth of cuts, and coolant needs. Make a 5- to 15-minute presentation explaining each of the process plan steps to be taken; identify all major components and functions of the machine tools; all major hand tools, measuring tools, surface finishes, and materials; and provide the rationale for the selected speeds and feeds, depth of cuts, and coolant needs.

2.1 **Module 2: Manual Operations** 40

Designed to provide basic skills needed for using hand tools and performing benchmetal work. Included is the use of arbor presses, work holding and hand tools, hacksaws, files, reamers, taps and dies, finishing tools, bushings, bearings, and assembly tools.

2.1.1 **Manual Operations: Benchwork** - Tap holes. Use files, scrapers, and coated abrasives to deburr parts. Use arbor presses to perform interference fits. Use bench vises and hand tools appropriately.

Performance Standard: Given a process plan, a drawing, access to hand tools, a newly machined part with holes prepared for tapping, a hole prepared for press fit of a bushing, and a stud for one tapped

hole, deburr the part, tap the holes, press in the bushing, install the stud, and saw the stud to the length specified.

2.2.0 **Manual Operations: Layout**

Designed to provide basic skills for laying out hole locations, radii, and surfaces to match the drawing and specifications. The student is required to perform all work necessary to produce the part given the raw material, drawing, process plan, layout tooling, and measuring instruments.

Manual Operations: Layout – Lay out the location of hole centers and surfaces with an accuracy of $\pm .015$.

Performance Standard: Given a surface plate, surface gage, layout height gage, combination set, scribe, layout ink, prick punch, ball peen hammer, process plan, and drawing, the student is required to lay out hole locations, radii, and surfaces matching the specifications.

3.1 **Module 3: Turning Operations**

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Designed to provide basic skills needed for operating standard engine lathes. Given access to an appropriate turning machine and accessories, raw material, process plan, drawing, precision measurement, and cutting tools, the student performs all practices necessary to produce a part are required.

Turning Operations: Between Centers Turning - Set up and perform straight turning operations between centers.

Performance Standard: Given raw material, process plan, drawing, hand, precision, and cutting tools, and access to an appropriate engine lathe and its accessories, the student is required to produce a part matching the process plan and the drawing specifications using appropriate trade practices, safety procedures, speeds and feeds, depth of cuts, and coolant needs. The specified part should have at least three diameters within $\pm .001$, one Unified National Coarse (UNC) external thread, and one Unified National Fine (UNF) external thread and require an end-for-end swap.

Turning Operations: Chucking – Set up and perform chucking operations for turning.

Performance Standard: Given access to a appropriate engine lathe and its accessories, raw material, process plan, drawing, hand, precision, and cutting tools, the student is required to produce a part matching the process plan and the drawing specifications using proper trade practices, speeds and feeds, depth of cuts, and coolant needs. The specified part should have at least three diameters within

+/- .005, one bore within +/- .005, and one UNC external and one UNF internal thread, and require at least two chuckings or other work holding setup. The part shall be repositioned at least once during the machining operation.

4.1 Module 4: Milling Operations

70

Designed to provide basic skills needed for operating standard vertical and horizontal milling machines. All work is required to produce a part given the raw material; process plan; and drawing, tooling, and measurement instruments.

4.1.1 Power Feed Milling: Set up and operate a horizontal or vertical milling machine using power speeds and feeds, depth of cuts, and coolant needs. Perform routine milling.

Performance Standard: Given access to an appropriate milling machine and its accessories; raw material; process plan; and drawing, hand, precision, and cutting tools, the student is required to produce a part matching the process plan and the drawing specifications. The specified part should require squaring up from the raw state and significant material removal. Depth of cuts between .200" and .250" will be required.

4.2.1 Vertical Milling: Set up and operate vertical milling machines. Perform routine milling, and location of hole centers within +/- .005".

Performance Standard: Given access to an appropriate milling machine and its accessories; raw material; process plan; and drawing, hand, precision, and cutting tools, the student is required to produce a part matching the process plan and the drawing specifications using proper trade practices, speeds, feeds, depth of cuts, and coolant needs. The specified part should require squaring up from the raw state, have at least one milled slot, require the location of at least two drilled and reamed holes within +/- .005" and have three steps controlled by tolerances of +/- .005".

5.1 Module 5: Surface Grinding Operations

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Designed to introduce the basic operations of a standard surface grinder. Requirements are to (1) select, mount, and dress a grinding wheel and (2) produce a part given a block squared on a mill, a process plan, a drawing, and hand and precision measuring tools.

Surface Grinding, Grinding Wheel Safety - Ring test grinding wheels, perform visual safety inspection, mount and dress a grinding wheel in preparation for surface grinding.

Performance Standard: Given a selection of wheels in various conditions, the student is required to determine which wheels are suitable for use, mount one on the spindle, and dress it in preparation for surface grinding.

- 5.2.1 Surface Grinding, Horizontal Spindle, Reciprocating Table:** Set up and operate manual surface grinders with a 10" and smaller-diameter wheel. Perform routine surface grinding, location of surfaces, and squaring of surfaces. Perform wheel dressing.

Performance Standard: Given a block squared up on a mill; a process plan; drawing, hand, and precision tools; choice of grinding wheels; access to a surface grinder and its accessories; the student is required to dress the wheel and produce a part matching the process plan and drawing specifications using proper trade practices. The specified part would be in a semifinished state, having been squared. Finishing the part will require the precision finishing of the six faces of the block to tolerances common to precision grinding for squareness, size, and surface finish characteristics.

- 6.1 Module 6: Drill Press Operations** **20**
Designed to introduce the basic operation of standard sensitive and power feed presses. Requirements are to produce a part given the raw material; process plan; drawing, tooling, and measuring instruments.

- 6.1.1 Drill Press:** Set up and operate drill presses. Perform routine drill press operations.

Performance Standard: Given access to a drill press and its accessories; a semifinished part; a process plan; and drawing, hand, precision, and cutting tools; the student is required to produce a part matching the process plan and the drawing specifications. The specified part would be in a semifinished state, having been squared up and the outer surfaces completed with four center-drill locations. Finishing the part will require finishing of the four center-drilled locations and layout of a fifth location. Each hole must have at least two secondary operations. The secondary operations will consist of reaming, spot facing, countersinking, counterboring, and counterdrilling. At least one hole must be a blind hole and one a through hole. The fifth hole, a through hole, must have its location center-punched, center-drilled, and finished from the layout. The fifth hole will be power tapped.

- 6.2.1 Power Saw Operation**
Set up and operate power saws for cutoff operations.

Performance Standard:

Given a length of bar stock, a process plan, drawing, hand and basic measuring tools, and a power saw with an appropriate blade installed, the student is required to cut a length of material matching the cut list on the process plan.

7.1 Module 7: Quality Control, Inspection, and Process Adjustment 25

Designed to provide skills needed for basic inspection of machined parts and the process control, adjustment, and improvement of the machining processes used to manufacture those parts. Emphasis will be on teamwork, quality control, and continuous improvement. All participants will be required to work as team members and prove or disprove their suggestions.

7.1.1 Part Inspection: Develop an inspection plan and inspect simple parts using precision tools and practices. Prepare reports on the compliance of the parts.

Performance Standard: Given the necessary task process sheets for a part and oral instructions, the student is required to identify and select the required measuring instruments and conduct the required inspection procedure(s). Complete required written inspection report and make a decision to accept or reject component parts. Provide brief verbal explanation of inspection procedures, results, and decisions.

7.2.1 Process Control: The student is required to follow a sampling plan, inspect the samples for the required data, enter the data on appropriate charts, graph the data, and respond to the warning conditions indicated by the process charts.

Performance Standard: Given access to an appropriate milling machine and its accessories; raw material; process plan; drawing; hand, precision, and cutting tools; the student is required to produce a part matching the process plan and the drawing specifications using proper trade practices and speeds and feeds, depth of cuts, and coolant needs. The specified part should require squaring from the raw state, have at least one milled slot, require the location of at least two drilled and reamed holes within $\pm .005$ " and have three steps controlled by tolerances of $\pm .005$ ". Geometric tolerancing practices should be included in the process.

7.3.1 Participation in Process Improvement: As a member of a process team, analyze the performance of a production process. The team shall formulate process adjustments for improvements where appropriate. When appropriate, the student is required to notify the supervisor of the proposed adjustments and/or improvements. Where authorized, perform the strategies for process adjustment and/or improvement.

Performance Standard: As a team member that has been given a process plan, drawing, inspection process plan, oral instructions, the necessary tools and equipment, and a routine production process having a problem(s), the student is required to analyze the problem(s), propose remedies, obtain authorization to implement the process improvement(s), and produce the object. Perform the cause-and-effect analysis by participating in the development of a fishbone diagram with the team. Explain the fishbone diagram, the corrective actions, and the reasoning connecting the fishbone root cause analysis to the remedial actions taken.

8.1 Module 8: General Maintenance 15

An introduction to all issues in general housekeeping, preventive maintenance, and tooling maintenance in the metalworking field. Demonstration of appropriate actions regarding benchwork and layout areas, conventional lathe areas, computer numerical control (CNC) machine areas, and the general facility is required. Maintenance of specific machines and tooling will be required along with general preventive maintenance procedures.

8.1.1 General Housekeeping and Maintenance: Keep workstations clean and safe. Keep tools, workbenches, and manual equipment clean, maintained, and safe.

Performance Standard: Given maintenance, cleaning, and housekeeping checklists, and oral instructions, the student is required to clean, maintain, and respond appropriately to safety hazards on all benchmetal work tools, conventional, and CNC machine tools. Maintain cleanliness of the general work area.

8.1.2 Preventive Maintenance and Machine Tools: Inspect and assess the general condition of an assigned machine tool. Make routine adjustments as necessary and as authorized. Report problems to supervision that are beyond the scope of authority. Perform daily, weekly, and/or monthly routine upkeep chores cited on checklists for a given machine tool.

Performance Standard: Given the preventive maintenance procedures and schedules for a given machine tool and sufficient instruction and experience to recognize maintenance problems, the student is required to perform routine maintenance, report problems that are beyond the scope of authority, complete maintenance history forms. Make an oral presentation explaining the condition of the machine and the actions taken.

8.1.3 Tooling Maintenance: Inspect and assess the condition of tooling. Refurbish tooling where appropriate. Refer tooling for repair or regrind where appropriate.

Performance Standard: Given samples of tooling in various conditions, diagnose the tooling, take the correct steps to place tooling back in service. Sample tooling should include turning, milling, drilling, and grinding tools. The tools should be both insert tooling and conventional tooling. The technician must demonstrate the offhand grinding of a drill between the diameter of .125" and 1.000". The offhand regrinding of a turning tool and the correct rotation and replacement of inserts in an insert style milling cutter body must be demonstrated. The technician must demonstrate the ability to recognize a cutting tool that needs reconditioning or sharpening on a tool and cutter grinder.

9.1 Module 9: Industrial Safety and Environmental Protection 15

Designed to introduce safety procedures used in the handling of work materials, operation of machines and tooling, and the handling and storage of hazardous wastes. Requirements are to demonstrate safe workplace practices given written and oral instructions.

9.1.1 Machine Operations and Material Handling: Perform assigned responsibilities while adhering to safe practices in accordance with Occupational Safety Health Administration (OSHA) requirements and guidelines. Document safety activities as required.

Performance Standard: Given written and oral safety instructions and checklists based on OSHA requirements and guidelines, the student is required to demonstrate safe workplace practices in material handling, machine operations, handling of tooling, handling and application of coolants, and cutting fluids and lubricants. Orally explain the actions taken that directly or indirectly bear upon safe practice in the execution of duties.

9.1.2 Hazardous Materials Handling and Storage: Handle and store hazardous materials as assigned while adhering to safe practices in accordance with OSHA and U.S. Environmental Protection Act (EPA) requirements and guidelines. Document safety activities as required.

Performance Standard: Given written and oral safety instructions detailing the handling and storage of hazardous materials in compliance with OSHA and EPA requirements and guidelines, demonstrate safe workplace practices in the identification, handling, and storage of hazardous materials.

10.1 Module 10: Career Management and Employee Relations 15

Designed to introduce career opportunities and functions of the metalworking industries. The learner will develop a career plan and an understanding of organizational structures and employment relationships. Interviewing skills and team skills will be practiced.

10.1.1 Career Planning: Develop and explain a short-term career plan and résumé.

Performance Standard: Given written information, presentations, and informational interviews with industry representatives on career opportunities in the metalworking industry, develop a short-term career plan (1-4 years), including career objectives, training and education, and employment opportunities. Develop a résumé appropriate for the metalworking industry based on the career plan. Make an oral presentation of the career plan and résumé.

10.1.2 Job Application and Interviewing: Complete job application form and demonstrate interviewing skills.

Performance Standard: Given a job description and a standard application, the student is required to complete the application form. Identify and demonstrate appropriate interviewing skills in an interview with a company representative.

10.1.3 Teamwork and Interpersonal Relations: Demonstrate appropriate interpersonal skills in job performance evaluations, group communication and decision making, and conflict resolution.

Performance Standard: Given written and oral information about a machining technician in a work unit, demonstrate appropriate interpersonal skills in three simulated cases involving a supervisor or team leader and other team members: (1) receiving feedback on job performance in a formal evaluation process; (2) actively participating in a group decision-making process involving appropriate communication and feedback skills with other team members; and (3) resolving conflicts with supervisors and team members.

10.1.4 Employment Relations: Understand and explain employment rights and responsibilities in metalworking companies.

Performance Standard: Given written and oral information on employment rights and responsibilities (similar to those contained in employee handbooks), answer questions about hiring and promotion requirement, dismissal and layoff policies, compensation schedules and amounts, and substance abuse policies.

11.1 Module 11: Industry Experience

Expand knowledge and experiences working in a machining/manufacturing environment utilizing cooperative education and/or community classroom methodologies.

180

Total Hours: 360 hours of classroom instruction and 180 hours of work-based learning

1.0 CONTENT COMPETENCIES – LEVEL II

30

1.1 Module 1: Job Planning and Management

Designed to allow hands-on skill advancement. Emphasis will be on part process planning and capability studies. Development of a working knowledge of part routing and process planning sheets is required. Participation as a team member in capability studies using and interpreting statistical data is also required.

Job Process Planning: Write a detailed process plan that includes a quality plan for a part requiring milling, drilling, turning, or grinding. Produce an operation sheet detailing the process plan and required speeds, feeds, depths of cuts, and coolant needs. Provide sketches as needed.

Performance Standard: Given a drawing detailing a part requiring milling, drilling, turning, grinding, oral instructions, and appropriate references, the student is required to formulate a set of strategies to manufacture the part and write a detailed process plan, including the quality plan for that part. Provide sketches as needed. Make a presentation explaining each of the process plan steps to be taken; identify all major components and functions of the machine tools; all major hand tools, measuring tools, tools, fixtures; work materials; and provide the rationale for the selected speeds and feeds, depth of cuts, and coolant needs.

1.2 Participate in Capability Studies: Participate as a team member in a capability study. Perform the required statistical calculations to support the capability study. With the assistance of the team leader, prepare the necessary shop reports for the capability study.

Performance Standard: Given needed capability studies and the data collected to satisfy the needs of that study, participate as a team member in support of the study. With the direction of the team leader, provide all the machining expertise and statistical calculation needed to satisfy the requirements of the capability study.

2.1 Module 2: Manual Operations

35

Designed to provide hands-on skill advancement in layout practices and operations. Emphasis will be on bolt hole circles, location of surfaces related by nonright angles, and points of tangency. The student must perform practices necessary to lay out a part given raw material; process plan; and drawing, tooling, and measuring instruments.

2.1.1	Lay out Bolt Circles, Angles, Tangency Points, Line Profiles:	
	Set up and lay out bolt circles, locations of surfaces related by nonright angles, locations of points of tangency between arcs and lines, and profiles of a line which are non arc-based.	
	Performance Standard: Given a surface plate, surface gage, layout height gage, combination set, scribe, layout ink, prick punch, ball peen hammer, process plan, and drawing, the student is required to lay out a block of material that includes a flange face fixture with a 12-hole blot circle, two examples of tangent radii (one a fillet and the other an external radius), and defined profile of a line with approximating arcs and the coordinates supplied.	
3.1	Module 3: Band Saw Operation	15
	Designed to provide hands-on skill advancement in the operations of standard band saws. This module will emphasize contour band sawing and blade welding. The student must perform practices necessary to produce a part given raw material, process plan, drawing, tooling, and measuring instruments.	
3.1.1	Contour Band Sawing: Set up and perform contour sawing according to the layout. Choose and mount appropriate blades. Weld, break, and reweld blades as necessary.	
	Performance Standard: Given a part with a finished layout and access to an appropriate band saw and blades, the student is required to finish saw the part according to the layout.	
4.1	Module 4: Turning Operations	30 20
	Designed to provide hands-on skill advancement in lathe operations. Produce outside and inside diameter tapers, using a taper turning attachment, production turning, and turning between centers.	
4.1.1	Turning Operations, Between-Centers Taper Turning: Set up and perform operations between centers turning for straight and tapered turning by offsetting the tailstock.	
	Performance Standard: Given access to an appropriate turning machine and its accessories; raw material; process plan; and drawing, hand, precision, and cutting tools; the student is required to produce a part matching the process plan and the drawing specifications using proper trade practices, speeds, feeds, depth of cuts, and coolant needs. The specified part should have at least two straight diameters within +/- .001" and appropriate taper at each end of the part, and require an end-for-end reversal of the part.	

5.1	Module 5: Milling Machine Operations Designed to provide hands-on skill advancement in the operations of standard horizontal milling machines. Produce a part when given the raw material, process plan, drawing, tooling, and necessary measuring instruments.	30	25
5.1.1	Horizontal Milling, Square Up a Block: Set up and perform squaring six surfaces of a block to within a $\pm .002$ " and $.002$ " over 4" tolerance. Performance Standard: Given an appropriate milling machine and its accessories; raw material; process plan; drawing; and hand, precision, and cutting tools; the student is required to produce a part matching the process plan and drawing specifications. The part will require being squared from the raw state.		
5.1.2	Horizontal Mill, Cut a Key Seat: Set up and perform milling key seats on a shaft. Performance Standard: Given an appropriate milling machine and its accessories; raw material; process plan; drawing; and hand, precision, and cutting tools; the student is required to produce a part matching the process plan and the drawing specifications using proper trade practices, speeds and feeds, depth of cuts, and coolant needs. The specified part would require milling two key seats whose characteristics match the American National Standards Institute (ANSI) B17.1 keys and key seat standards.		
5.1.3	Horizontal mill, Cut a Deep Slot with a Stagger Tooth Cutter: Set up and perform the cutting of a deep slot using a stagger tooth cutter. Performance Standard: Given access to an appropriate milling machine and its accessories; raw material; process plan; drawing; and hand, precision, and cutting tools, the student is required to produce a part matching the process plan and the drawing specifications. The specified part will require milling three deep slots: two parallel to one another and a third at right angles to the first two.		
6.1	Module 6: Milling Attachment Operations Designed to provide skill advancement in the operations of standard vertical milling machines. Common milling attachments and their use will be emphasized. Use of rotary tables, dividing and boring heads will be understood in detail. Perform tasks necessary to produce a part given raw material, process plan, drawing, tooling, and measuring instruments.	60	25
6.1.1	Vertical Milling, Precision Location of Holes: Set up and perform boring for location, size, and finish.		

Performance Standard: Produce three bores to specification. The part will specify 3 holes in a 1" plate. The holes will be between $\frac{3}{4}$ " and 1- $\frac{1}{2}$ " to locations within $\pm .0005$ ". One hole is to be counterbored to a decimal depth holding $\pm .002$ " and counterbored diameter within $\pm .005$ ".

- 6.1.2 Vertical Mill, Use Rotary Tables:** Set up and perform the development of surfaces at a specified nonright angle using a rotary table. Set up and establish hole locations in various relationships to one another using a rotary table. The holes are in the same plane. Establish the profile of a radius for two surfaces and the connecting points of tangency.

Performance Standard: Given access to an appropriately sized rotary table; accessories; raw material; process plan; and drawing, hand, precision, and cutting tools; the student is required to produce a part matching the process plan and the drawing specifications. The specified part will require two groups of holes arranged on bolt circles as well as several surfaces at various angles to one another.

- 6.1.3 Vertical Mill, Dividing Head Operations:** Set up and perform operations requiring a dividing head. Set up and establish hole locations in various relationships to one another using a dividing head. Establish the profile of a radius for two surfaces and connecting points of tangency.

Performance Standard: Given access to an appropriately sized dividing head and accessories; raw material; process plan; drawing; and hand, precision, and cutting tools; the student is required to produce a part matching the process plan and the drawing specifications. The specified part will require two groups of holes arranged on an outer diameter and several surfaces at various angles to one another.

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| 7.1 | Module 7: Horizontal Milling Machine Operations | 15 | 10 |
| | Designed for skill advancement in the operations of standard horizontal boring mill machines. Tooling, adjustable boring heads, and precision boring operations will be emphasized. The student is required to perform all work necessary to produce a part given raw material, process plan, drawing, tooling, and measuring instruments. | | |
| 7.1.1 | Basic Horizontal Boring Mill Operations: Set up and perform boring for location, size, and finish and mill a slot for location and size. | | |

Performance Standard: Produce three bores: Of the three bores, one must have counterbore of $\pm .002$ ", and one must have a slot to specification.

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| 8.1 | Module 8: Grinding Operations | 30 | 25 |
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- Designed to provide skill advancement in the operations of standard surface and cylindrical grinding machines. This module will emphasize grinding wheel selection and preparation and precision grinding practices for flats, angles, and straight diameters. The student is required to perform all work necessary to produce a part given raw material, process plan, drawing, tooling, and measuring instruments.
- 8.1.1 Surface Grinding, Finish Flats to $\pm .0005''$:** Grind a block's six faces to finished dimensions having tolerances of $\pm .0005''$ and squareness of $.0005''$ over 4" and 32 micro inch surface finish. Dress the wheel as necessary.
- Performance Standard:** Given a block squared up on a mill and hardened 55 to 60 Rockwell; a process plan; drawing; hand, and precision tools; a choice of grinding wheels; access to a surface grinder and accessories; dress the wheel; the student is required to produce a part matching the process plan and the drawing specifications using proper trade practices. The part will require the precision finishing of the six faces of the block to tolerances common to precision grinding for squareness, size, and surface finish characteristics.
- 8.1.2 Surface Grinding, Finish Flats at Simple Angles:** Set up and perform the finish surface grinding of flat surfaces at simple angles relative to one another. Dress the wheel as necessary.
- Performance Standard:** Given a block roughed out on a mill; a process plan; drawing; hand and precision tools; and choice of grinding wheels; access to a surface grinder and accessories; the student is required to dress the wheel and grind the specified angled surfaces to a finish matching the process plan and the drawing specifications using appropriate trade practices. The specified part would be a semifinished state having been roughed out. Finishing the part will require the precision finishing of the specified surfaces of the block to tolerances common to precision grinding for squareness, size, and surface finish characteristics.
- 8.1.3 Grinding Wheel Preparation and Balancing:** Set up and perform the balancing operation of a 14" or greater diameter grinding wheel. Place the wheel into service.
- Performance Standard:** Given a wheel and appropriate equipment prepare the wheel to go into service. Mount the wheel. Produce a surface finish of 32 micro inches or better on a cylinder of cold rolled steel.
- 8.1.4 Cylindrical Grinding:** Set up and perform between centers grinding for straight diameters. Dress the wheel as necessary.

Performance Standard: Dress the wheel. Given a part rough finished on three diameters, mount the part between centers, and grind the required diameters to finish.

9.1	Module 9: Radial Drill Operation	15	10
	Designed to provide hands-on skill advancement in the operations of standard radial drills. Drilling, reaming and power tapping will be emphasized. The student must perform all practices necessary to produce a part given raw material; a process plan; and drawing, tooling, and measuring instruments.		
9.1.1	Drilling, Radial Drill: Set up and perform drilling operations using a radial drill.		
	Performance Standard: Set up, center drill, drill, countersink, and tap a series of holes to drawing specification. Perform other operations as required by the drawing.		
10.1	Module 10: Electro Discharge Machine (EDM)	5	25
	Designed to introduce hands-on skill advancement in the operations of standard electromechanical discharge plunge, and two-axis wire EDM machines. The set up and operation of EDM machines will be emphasized. All practices necessary to produce a part given raw material; a process plan; and drawing, tooling, and measuring instruments.		
10.1.1	EDM, Operate a Plunge EDM: Operate a plunge electric discharge machine.		
	Performance Standard: Given a print, process plan, an appropriate selection of electrodes, work-holding devices, EDM fluids, and plunge EDM machine, the student must perform the EDM operation called out on the process plan.		
10.1.2	EDM, Operate a Two-Axis Wire EDM: Operate a two-axis wire Electric Discharge Machine.		
	Performance Standard: Given a print, process plan, a selection of wire electrodes, work-holding devices, EDM fluids, and two-axis wire EDM machine, the student must perform the EDM operation called out on the process plan.		
11.1	Module 11: Computer Numerical Control Mill (CNC)	50	20
	Designed to introduce hands-on skill advancement in the operations of standard CNC milling machines. CNC mill programming and CNC mill operation will be introduced. The student performs all practices		

necessary to produce a part given raw material; a process plan; and drawing, tooling, and measuring instruments.

- 11.1.1 CNC, Write Simple RS274-D Programs:** Using a computer and editor software, write simple RS274-D programs. Simple programs are single plane, cutter centerline, linear and circular interpolation, and single cutter, with no canned cycles.

Performance Standard: Given a drawing with the tool path shown, and computer with editor software, the student is required to write a program, including speeds, feeds, depth of cuts, and coolant needs, to drive an end mill through a continuous path around three sides of a part requiring the development of a linear interpolation tool path and circular interpolation. Store the program on computer media.

- 11.1.2 CNC, Operate a CNC Milling Machine:** Operate a CNC milling machine.

Performance Standard: Given a CNC mill with a qualified setup and functioning program, the student is required to operate the mill, change tool values as necessary, and replace and qualify tooling as necessary.

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| 12.1 | Module 12 CNC Turning Center Operations | 50 | 20 |
| | Designed to introduce hands-on skill advancement in the operations of standard CNC turning center. CNC turning center programming and operation will be introduced. The student performs all practices necessary to produce a part given raw material; a process plan; and drawing, tooling, and measuring instruments. | | |

- 12.1.1 CNC, Write Simple RS272-D Programs:** Using a computer and editor software write simple RS274-D programs. Simple programs are single plane, cutter centerline, linear and circular interpolation, and single cutter, with no canned cycles.

Performance Standard: Given a drawing with the tool path shown and computer with editor software, the student is required to write a program, including speeds and feeds, depth of cuts and coolant needs, to drive a cutting tool through a continuous path to produce a part requiring the development of a linear interpolation tool path and circular interpolation. Store the program on computer media.

- 12.1.2 CNC, Operate a CNC Turning Center:** Operate a CNC turning center.

Performance Standard: Given a CNC turning center with a qualified setup and functioning program, the student is required to operate the turning center, change tool values as necessary, and replace and qualify tooling as necessary.

13.1 Module 13: Industry Experience

Expand skill levels working in a machining/manufacturing environment using cooperative education and/or community classroom methodologies.

Total Hours: 360 hours of classroom instruction and 170 hours of work-based learning

Total NIMS Precision Machining course hours: 1,080